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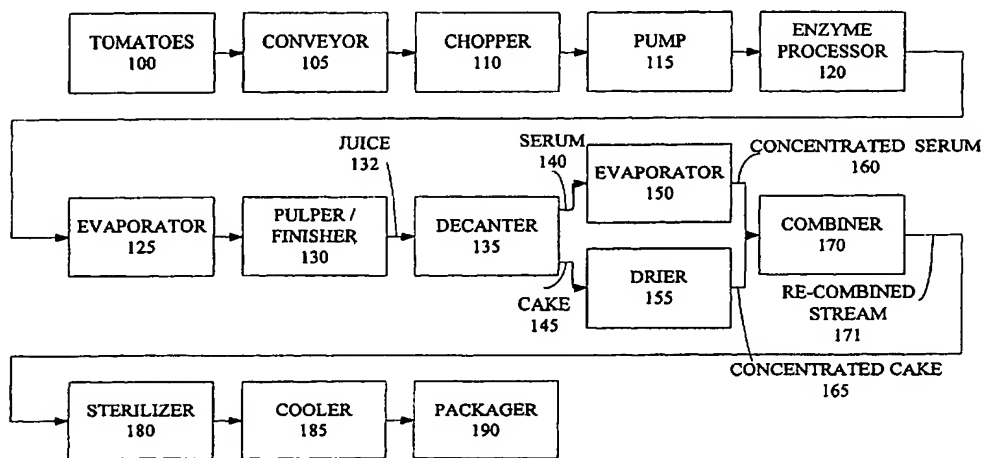
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(54) Title: **SYSTEM AND METHOD FOR PRODUCING CONCENTRATED FOOD PRODUCTS WITH FRACTIONATION  
CONCENTRATION**



(57) Abstract: An improved processing method and system for producing tomato paste and other food products affected by viscosity. Tomatoes are processed into tomato juice. The juice is provided to a decanter that separates or fractionates the juice into two portions - a thicker, more viscous cake portion and a thinner, less viscous serum portion. The serum portion is concentrated by removing a portion of water using an evaporator such as a thin film or juice evaporator. The cake portion can be concentrated if necessary with a drier. The serum and cake portions are recombined to produce a tomato paste having improved color, texture, flavor and nutrition.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

1                    SYSTEM AND METHOD FOR PRODUCING CONCENTRATED FOOD  
                      PRODUCTS WITH FRACTIONATION CONCENTRATION

5                    FIELD OF THE INVENTION

                      This invention relates to food products and a system and method for producing food products. In particular, the present invention relates to tomato paste and similar food items that are produced by separating tomatoes or food items into portions or fractions having different viscosity, concentrating one or more of the portions, and re-combining the portions to form a food product such as tomato paste.

10                   DESCRIPTION OF RELATED ART

                      Tomatoes or derivative tomato products such as juice, puree and paste can be added as food ingredients to a food product to provide, for example, flavor, color, texture and viscosity. Tomato paste is one common product produced from tomatoes. To produce tomato paste, water is typically removed from tomatoes or tomato juice via dehydration or evaporation.

15                   Using tomato paste can be advantageous, compared to fresh tomatoes or tomato juice, for a number of reasons. For example tomato paste may provide improved taste, appearance, and be advantageous for the following economic considerations:

20                   a.      Storage capabilities - aseptically bulk packaged tomato paste can be stored for extended periods of time (e.g., up to several years) prior to consumption. These storage capabilities provide flexibility in shipping, transportation, and sales.

                      b.      Reduced shipping costs - bulk tomato paste typically weighs less than raw tomatoes as a result of lower water content. Thus, shipping costs are reduced.

25                   c.      Supply flexibility - a year round supply of tomato paste can be maintained in spite of the season for harvesting fresh tomatoes being approximately 100 days.

                      d.      Cooking requirements - some products require tomato paste rather than fresh tomatoes or tomato juice based on a recipe's water content limitations.

30                   Known system typically process tomatoes by directly processing the entire or unfractionated tomato stream. For example, tomatoes are chopped into a liquid or liquid-like product and supplied to an evaporator. The unfractionated tomato stream becomes increasingly concentrated as the evaporator heats the tomato stream and removes water from the stream.

35                   Such conventional systems, however, typically have a number of shortcomings. First, as the paste product becomes more viscous (thicker or more resistant to flow), the tomato paste becomes increasingly more difficult to manipulate. The increasing viscosity is the result of vacuum, heat, shear and recirculation of the thickening paste. Portions of the paste can be "burned" onto evaporator surfaces as the surfaces are heated and the viscous paste can stick to

1 the surfaces. Consequently, the resulting tomato paste can be burned or overheated, resulting in diminished tomato paste quality, e.g., reduced color, flavor and nutrients.

Moreover, additional cleaning and maintenance of evaporator equipment may be necessary as a result of the "burning" effect. Maintenance and cleaning requires additional time  
5 and resources which, in turn, lead to inefficient processing and reduced production capabilities. Additionally, in order to process the increasingly viscous paste, known systems typically use more powerful evaporators that can handle higher viscosity paste. These types of evaporators may use re-circulation turbine pumps to pump and re-circulate the increasingly viscous tomato paste. These more powerful, larger evaporators usually are more expensive. Further, larger  
10 evaporators typically consume more power and are more expensive to operate. Additionally, processing unfractionated streams of tomato juice typically takes a significant amount of time (e.g., two to three hours for a reasonable sized batch). Consequently, systems that produce tomato paste by directly processing unfractionated streams of juice often are not time, cost, and energy efficient and can produce lower quality tomato paste.

Other known systems separate portions of tomato paste to form derivative products. For example, a portion can be removed from a tomato juice stream, and the evaporator can concentrate the remaining portion. Typically, however, these known systems also have a number of shortcomings. First, these systems produce separated components that are useful only in limited circumstances based on the quality and nature of the components. For example, the  
20 thicker component is typically a dense, powder-like substance that can be milled and used as a flavoring. The thicker component, however, is often not suitable for tomato paste. Further, the remaining portion is often too thin to be used as tomato paste. Thus, these known systems separate components of a tomato stream, but may not be able to produce tomato paste in an effective manner. Further, the dense powder and liquid components typically cannot be combined  
25 due to their different compositions. If the portions are combined, a low quality, chalky tomato paste-like product may be produced having diminished color, texture, and taste. Thus, known systems that separate tomato components are often not as effective as desired to produce quality tomato paste in an efficient manner.

There is a need, therefore, for a system and a method for producing tomato paste and  
30 other similar products with improved viscosity, color, nutrients and flavor in a more cost, energy and time efficient manner.

#### SUMMARY OF THE INVENTION

The present invention provides an improved system and method for processing tomato  
35 products to produce a paste with enhanced taste and color in a more efficient manner.

One embodiment of the present invention provides a system and method that processes

1 tomatoes into a stream of tomato "juice." The juice stream is separated or fractionated into two  
portions - a serum portion and a cake portion. The serum portion has a lower viscosity than the  
cake portion. In other words, the cake portion is thicker and more resistant to flow relative to the  
serum portion. After these portions are separated, the serum portion is concentrated using, for  
5 example, an evaporator. The cake portion can also be concentrated, if desired, using a drier  
mechanism or other suitable evaporator. The cake portion and the concentrated serum portion  
are re-combined to form an improved tomato paste. Alternatively, the portions can be separately  
processed and/or packaged as separate products or ingredients.

The cake portion includes a majority of insoluble solids relative to the serum portion. As  
10 a result, the serum portion can be concentrated more easily with an evaporator for enhanced  
appearance and taste. Further, less evaporation time and energy are required to process the serum  
portion, thereby reducing capital and energy costs associated with the evaporator. Thus, less  
expensive and robust evaporators can be used. A drying mechanism can be used to concentrate  
the cake instead of an evaporator. As a result, the present invention can reduce or eliminate  
15 degradation of tomato juice stream resulting from "burn on" of cake components onto evaporator  
surfaces. Further, cleaning and maintenance costs can be reduced while producing a tomato paste  
product with enhanced flavor, texture, color and nutrition.

Also in accordance with the present invention, a decanter can be used to separate tomato  
juice into cake and serum portions. The decanter can separate the portions using different  
20 techniques. One exemplary decanter is configured as a centrifuge with an inner weir. As the  
centrifuge rotates, the cake gravitates to the inner surface of the decanter and is separated from  
the serum with the weir. The fractionated cake portion can advantageously have the following  
characteristics: about 5%-35% of the tomato stream by weight, about 5%-60% insoluble solids  
by weight, about 3%-16% soluble solids by weight and a concentration of about 3-13 brix. The  
25 fractionated serum portion can have the following characteristics: about 65%-95% of the tomato  
stream by weight, about 0(trace)-10% insoluble solids by weight, about 3%-17% of soluble solids  
by weight and a concentration of about 3-16 brix.

In further accordance with the invention, if the cake and serum streams are re-combined,  
the concentration of the re-combined stream can have a concentration of about 15-40 brix. If the  
30 cake and serum portions are not re-combined, the cake portion can have a concentration of about  
5-99% of solids. For example, a thick cake can be formed if the cake portion is about 5% solids,  
whereas a powder that can be milled can be formed if the cake portion is about 99% solids. The  
serum portion can be concentrated to a concentration of about 22-75 brix.

## 1 BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent corresponding parts throughout:

5 FIG. 1 is a general block system diagram of portions used to process a stream of tomato juice by fractionating the juice into cake and serum portions, and re-combining the portions to form a tomato paste;

FIG. 2 is a general block system diagram of portions used to process tomato juice by fractionating the juice into cake and serum portions, and separately processing the portions;

10 FIG. 3 is a system diagram illustrating one example system configuration and example operating parameters;

FIG. 4 is a diagram illustrating an example decanter configuration for fractionating a tomato juice stream into cake and serum portions;

15 FIGS. 5A-B are flow diagrams illustrating a method of producing tomato paste by separating the tomato juice stream into cake and serum portions, and re-combining the portions to form tomato paste; and

FIGS. 6A-B are flow diagrams illustrating a method of separating the tomato juice stream into cake and serum portions, and separately processing the portions.

## DETAILED DESCRIPTION

20 In the following description of embodiments of the invention, reference is made to the accompanying drawings which form a part hereof, and which is shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments can be utilized as structural changes may be made without departing from the scope of the present invention.

25 One aspect of the invention provides a processing system that fractionates or separates tomato juice or a tomato stream or other similar substance into different portions, i.e., cake and serum portions, and later re-combines the portions. As generally illustrated in Figure 1, the processing system transports a product 100, such as tomatoes, on a conveyor or other transport system 105. Those persons of ordinary skill in the art will recognize that various tomato products  
30 100 can be processed, such as fresh tomatoes, tomato juice, tomato slurry, a mixture of tomato juice and tomato pulp, or other tomato derivatives. However, the invention is not so limited. Those persons of ordinary skill in the art will also recognize that other food products can be processed. For example, the present invention can be used to process or produce other food items that are affected by viscosity such as, for example, chili paste (which can be thicker than  
35 tomato paste), and other fruit or vegetables where limiting viscosities prevent or inhibit evaporation, such as peas for pea soup. A further example application of the present invention

1 is to process apples or apple cider to form a concentrated apple puree. The puree can be used to  
make apple pies and other apple products. However, for purposes of explanation, this  
specification refers to processing raw tomatoes into a "juice" that is fractionated into serum and  
5 cake portions that can be re-combined to form a tomato paste after one or more of the portions  
has been concentrated.

Tomatoes are transported along the conveyor and are chopped with a chopping  
mechanism 110. Chopped tomatoes are provided via a pump 115 to an enzyme processor 120  
for enzyme breaking or inactivation. The chopping mechanism 110 can be one of many  
mechanisms that chops tomatoes into tomato pieces including, but not limited to, a knife, a  
10 rotating knife, rotating blades, a blender mechanism, and other cutting and chopping devices  
capable of cutting fruits and vegetables. Alternatively, the chopper 110 and pump 115 can be  
combined into a single unit. For example, a device that combines both chopping and pumping  
functions is chopper pump model no. STH4R12S, available from Vaughn, Co., Inc., Montesano,  
Washington.

15 The enzyme processor 120 removes selected enzymes that affect the viscosity of chopped  
tomatoes. In other words, enzymes are inactivated during "hot breaking" or "enzyme breaking."  
Example enzymes that can be removed or inactivated include pectin galacturonase, pectin methyl  
esterase and other enzymes in fresh tomatoes. One exemplary enzyme processing or "breaking  
device" 120 that can be used is model G El Dorado, available from Rossi & Catelli S.P.A.,  
20 Parma, Italy. This exemplary enzyme breaking device can be set to operate at different  
configurations and temperatures for hot or cold breaking, as later described.

If necessary, the chopped tomatoes can be processed with an initial or preliminary  
evaporator 125. The initial evaporator 125 removes a portion of the water from the chopped  
tomatoes to make the tomatoes more viscous or thicker. One exemplary evaporator 125 that can  
25 be used for this purpose is a T.A.S.T.E. evaporator, available from FMC Food Tech, Inc., Citrus  
Systems Division, Lakeland, Florida. Another exemplary evaporator 125 that can be used is an  
EC series rising film evaporator, available from Tetra-Pak, Inc., Vernon Hills, Illinois.

Enzyme inactivated tomato pieces can be further processed and filtered using a pulper or  
finisher 130. One exemplary pulper/finisher 130 that can be used is a Butterfly TC6 depulper,  
30 available from Rossi & Catelli S.P.A., Parma, Italy. The pulper or finisher 130 removes solids  
from the tomatoes such as outer skins and/or seeds to form a tomato "juice" or "juice stream"  
132. More specifically, one type of the pulper/finisher 130 forces chopped tomatoes through a  
screen, filter, or filter screen having holes or apertures of specific size. Example screen sizes that  
can be used to remove seeds and/or peels to form the juice have apertures with dimensions of  
35 approximately 0.027" to 0.156". Most tomato seeds can be removed with screen having  
apertures of up to 0.074". As tomato pieces pass through the apertures, seeds and/or peels are

1 removed or filtered from the tomatoes to produce tomato juice 132. As a result, the juice 132 includes portions less than or equal to the size of the finisher-pulper 130 screen. Different food products can be processed with different pulper-finisher apertures depending on the quantity and size of seeds and desired smoothness or coarseness of fibers in the juice 132.

5 Those persons of ordinary skill in the art, however, will recognize that one or more of the portions 110-130 may not be necessary depending on the characteristics and type of tomato or food product processed. However, for purposes of explanation, this specification refers to the pulper/finisher 130 producing "tomato juice" 132, although juice 132 may be formed at different stages.

10 The tomato juice 132 is supplied to a decanting centrifuge 135 (hereafter referred to as decanter 135). The decanter 135 separates or fractionates juice 132 into a serum portion 140 and a cake portion 145. One exemplary decanter that can be utilized is a Tetra Aldex® decanter, model no. NX438, available from Tetra-Pak, Inc., Vernon Hills, Illinois. This example decanter uses a weir to separate the portions, as will be later described in further detail in connection with  
15 Figures 3 and 4. Another decanter that can separate tomato juice or tomato puree 132 into cake 140 and serum 145 portions is a clarifier decanter, model no. CA 755-0012 or model no. CA 755-01-12, available from Westfalia Separator, Inc., Northvale, New Jersey.

Those persons of ordinary skill in the art will recognize that various decanters and decanter configurations can be used. For example, instead of a centrifuge, the same fractionation  
20 technique can be achieved by using a press with one or more apertured filter screens (which can be used for processing apples or apple cider). A further alternative fractionation device can be a filtration membrane such as an ultrafiltration membrane. However, for purposes of explanation, this specification refers to a decanting centrifuge for fractionating a juice stream 132 into serum 140 and cake 145 portions.

25 The serum portion 140 is concentrated using an evaporator 150. The output of the evaporator 130 is a concentrated serum 160. Evaporator 150 can be the same as the initial evaporator 125 or similar. However, since the serum is thinner and less viscous than the cake portion or an unfractionated tomato stream, a smaller (and usually less expensive and more energy efficient) evaporator 125 can advantageously be used to concentrate the serum portion  
30 140. One exemplary evaporator 125 that can concentrate the serum portion 140 is a juice evaporator, Thermally Accelerated Short Time Evaporator (T.A.S.T.E.) 6 effect 6 stage available from FMCFoodTech Food Processing Systems, Parma, Italy. As a result of using a smaller evaporator, capital expenditures and energy costs for processing food products can be reduced. Further, concentration times can also be reduced since the serum is thinner than an unfractionated  
35 stream and easier to process in a shorter period of time. For example, some known systems may take an hour or more to process a batch of unfractionated tomatoes into a tomato paste.



1 However, the thinner, fractionated serum can be processed in less time with a smaller evaporator  
(e.g., 5 minutes – 1 hour).

5 The cake portion 145 can also be concentrated, if necessary with, e.g., a drier 155 to  
produce a dried cake portion 165. One exemplary drier 155 that can be used is a Refractance  
Window™ drier, available from MCD Technologies, Inc., Tacoma, Washington. With this  
exemplary drier, the cake 145 can be sprayed across the belt with a sprayer (not shown) and  
passed through the drier to evaporate water from the cake, thereby forming a concentrated cake  
portion 165. Other evaporation systems can also be used to concentrate the cake.

10 The concentrated serum portion 160 and the cake portion 145 (or concentrated cake 165,  
if desired) are re-combined using a combiner or combination unit 170 to form a re-combined  
stream 171 or tomato paste product. One exemplary combination unit 170 that can be used is  
a positive displacement pump, model no. 220, available from Waukesha Cherry Burrell Products,  
Delvan, Wisconsin. Alternatively, the combiner 170 can be an in-line static mixer, e.g., model  
no. SAN 42499, available from Komax Systems, Inc., Wilmington, California. Indeed, various  
15 combiners 170 can be used. The re-combined or second juice stream 171 output by the combiner  
170 is sterilized with a sterilization unit 180, as necessary, and cooled with a cooling mechanism  
or cooler 185, as necessary. The tomato paste can be packaged, shipped, stored for later  
consumption, or further processed as desired.

20 Referring now to Figure 2, in an alternative embodiment, the serum 140 and cake 145  
portions are not re-combined. Instead, the serum and cake portions are processed individually.  
More specifically, the juice stream 132 is processed by the decanter 135 to produce the serum  
140 and cake 145 portions as previously described. The serum portion 140 is concentrated with  
an evaporator 150 to produce a concentrated serum portion 160. The cake portion 145 can be  
concentrated, if necessary, with a drier to produce a concentrated cake portion 165. However,  
25 the cake and serum portions are then separately processed, e.g., are sterilized with one or more  
sterilizers 180, cooled with one or more coolers 185 and packaged with one or more packagers  
190. Thus, in this alternative embodiment, serum and cake portions are separately produced  
whereas tomato paste is ultimately produced by re-combining the portions as illustrated in Figure  
1. The resulting concentrated serum 160 can be used as a soup base or flavoring since it is  
30 thinner than the cake. The cake portion 145 or concentrated cake portion 165 can be used as a  
color ingredient, a source of nutritional fiber for foods including a tomato product, and a source  
of lycopene.

35 These and other aspects of the present invention are described in further detail with  
reference to the system and decanter diagram of Figure 4, and flow diagrams of Figures 5A-B  
and 6A-B.

1           Figure 3 illustrates one exemplary system configuration for processing tomatoes by re-  
combining the serum and cake portions to form the tomato paste. Of course, those persons of  
ordinary skill in the art will recognize that the following system parameters are merely illustrative  
of many system parameters and are not so limited. Further, Figure 3 illustrates the primary  
5           portions of the system. For example, depending on the state and type of tomatoes, chopping,  
pulp, and enzyme breaking may be performed. Additionally, one or more additional pumps  
may be used to direct the juice, serum portion, cake portion, and tomato paste product to the next  
processing portion.

10           Initially, tomatoes 100, are provided to an evaporator 125, such as a thin film evaporator,  
at a rate of about 112.4 tons per hour (tons/hr) at a concentration of about 5 brix. Different  
tomatoes with different brix concentrations can be processed, but the concentration of raw  
tomatoes can range from 3-7 brix. The concentration measurement "brix" refers to a percentage  
of sugar and other soluble solids present in the tomatoes. Thus, for example, tomato pieces  
having 3-7% sugar or soluble solids have a concentration of 3-7 brix. Tomato products having  
15           higher brix concentrations are generally sweeter and more flavorful as a result of higher sugar  
content.

20           The evaporator removes moisture from the tomatoes at a rate of about 50.0 tons/hr and  
outputs the tomatoes at about 62.4 tons/hr with a concentration of about 9 brix. The tomatoes  
can be processed by a pulper 130 resulting in a juice stream 132. The juice stream 132 is then  
processed by the decanter 135 at about 242 gallons per minute (gal/minute). The decanter  
fractionates the juice into serum and cake portions 140, 145 that are pumped through respective  
pumps 300, 305. The serum is pumped to an evaporator 150, such as a thin film / juice  
evaporator, at a rate of about 53.1 tons/hr at a concentration of about 9.0 brix. The cake 145 is  
pumped to a drier 155 at a rate of about 9.4 tons/hr at a concentration of about 9.0 brix. As  
25           previously mentioned, evaporator 150 can be a less robust (and less expensive) evaporator, such  
as a thin film juice evaporator, since it is processing the "thin" serum portion 140 of the juice  
stream 132. The evaporator 150 removes moisture from the serum 140 at rates of about 13.8  
tons/hr and 25.6 tons/hr, thereby concentrating the serum. The concentrated serum 160 exits the  
evaporator 150 at a rate of about 13.6 tons/hr at an increased concentration of about 35.0 brix.  
30           If needed, the concentrated serum 160 can be further concentrated with additional evaporators  
310 and 315. However, this example configuration does not utilize these additional evaporators  
as shown by consistent flow rates into the combiner 170, but are illustrated to show additional  
optional concentrating.

35           The drier 155 removes moisture from the cake 145 at a rate of about 1.8 tons/hr, resulting  
in concentrated cake 165 exiting the drier 155 at a rate of about 7.6 tons/hr with a concentration  
of about 11.2 brix. Those persons of ordinary skill in the art will recognize that the drier 155 is

1 optional. The concentrated serum 160 and the cake 145 or concentrated cake 165 are re-combined using combiner 170, such as a static mixer. The re-combined stream 171 includes about 64% serum by weight and about 36% cake by weight. The resulting stream 171 or tomato  
5 paste product exits the combiner 170 at a rate of 23.0 tons/hour with a concentration of 26.5 brix. Those persons of ordinary skill in the art will recognize that many variations on the previously described operating parameters can be used.

Turning to Figure 4, one exemplary decanter 135 includes a centrifuge body 400 supported by base 405. The centrifuge body 400 rotates around a bearing 410. The decanter includes an input 420, weir 430, serum output 440, cake output 450 and a scraping mechanism  
10 such as rotating auger 460.

Juice 132 is provided to the decanter 135 through the input 420. As the decanter rotates, the thicker cake portion is separated from the serum section. The cake portion gravitates to the inner surfaces 402 of the centrifuge body 400. The less dense serum portions remain in the general middle area of the decanter, i.e., the thinner serum does not tend to migrate to the inner  
15 surfaces of the centrifuge body. The cake portions 145 collecting around the inner surfaces 402 of the centrifuge body 400 are illustrated as dashed lines 145a in the top and bottom sections of the decanter cross section.

The weir 430 can be an interior wall or ring with an inner aperture 431. The weir serves as a wall to hold the cake and block it from exiting through the serum outlet 440. Thus, the weir  
20 separates the cake and serum portions and permits the less dense, thinner serum 140, to pass through the decanter through the serum outlet 440. The weir height is selected such that the cake portion is retained against the inner surface of the centrifuge body, thereby separating the cake from the serum. The cake can be removed from the decanter via cake output 450 near the bottom of the body. More specifically, the cake can be "scraped" off the inner surface of the rotating  
25 centrifuge bowls by, for example, a rotating scraper or auger 460 (partially illustrated in Figure 4). The auger surfaces rotate along the inner surface of the centrifuge body, thereby removing the cake 145a from the inner surface. The cake is then directed to the cake outlet or discharge port 450. The scraper can be configured to closely scrape the wall or be positioned further away from the inner surface such that the scraper removes a smaller quantity of cake from the inner  
30 surface of the centrifuge body. Cake and serum separation can be adjusted by adjusting the rotation speed of the decanter, rotating speed of the internal cake scraping auger (scroll speed differential), product temperature and the height of the weir.

One example decanter or centrifuge 135 that can be used is a Tetra Pak Inc., NX438 centrifuge operating at approximately 3400 revolutions per minute (rpm), having a 132  
35 millimeter (mm) pond depth weir plate and a scroll speed differential of 20-40 rpm. The separation efficiency of the decanter is improved as the temperature increases. A temperature

1 of approximately 180 to 190 degrees Fahrenheit typically results in separation of the cake and serum portions at the example speed.

Those persons of ordinary skill in the art will recognize that other scraping mechanisms can be utilized for removing cake from an inner surface of the centrifuge body. For example,  
5 instead of a rotating auger, the scraper can be a member that is displaceable along one or more of the inner top, bottom or side surfaces of the centrifuge body. Thus, the displaceable member can move from one end of the decanter to the other end to remove cake from the interior decanter surfaces.

Having described the general system portions and decanter configurations, Figures 5A-B  
10 and 6A-B illustrate the method for processing tomatoes with the system. Referring to Figure 5A, step 500, tomatoes are received and initially processed (e.g., cleaned, sorted, etc.). For example, a fruit dump with water flumes and a conveying elevator with water or cleaning sprays can be used. The tomatoes are transported to the chopping mechanism and, in step 505, are chopped into tomato pieces. Chopped tomatoes have a natural brix concentration of about 3-7 brix. Of  
15 course, different tomatoes and different food products can have different brix concentrations.

In step 510, enzymes are removed from or inactivated in the chopped tomato pieces. This process is referred to as "enzyme inactivation" or "enzyme breaking" or "hot breaking". More specifically, enzymes that are involved in the reduction of viscosity can be removed from or inactivated in tomato pieces, e.g., pectin galacturonase, pectin methyl esterase and other enzymes  
20 present in tomatoes that cause viscosity reduction.

Enzyme breaking can occur at "cold" or "hot" temperatures. In cold enzyme breaking, chopped tomatoes are subjected to approximately 150 to 170 degrees Fahrenheit for a period of about 1 to 10 minutes. In hot enzyme breaking, chopped tomatoes are subjected to approximately 200 to 230 degrees Fahrenheit for a period of about 15 seconds to 10 minutes.  
25 Whether hot or cold enzyme breaking is used can depend on the desired viscosity effect. For example, tomato paste made from "hot broken" tomatoes typically has higher viscosity than "cold broken" tomatoes. However, tomato paste produced with hot broken tomatoes typically has less vibrant color than tomato paste produced with cold broken tomatoes. Breaking parameters can be adjusted depending on operating parameters and the desired enzyme breaking  
30 effect.

Continuing with block 515, chopped and enzyme inactivated tomatoes are processed with a pulper or finisher, if necessary. The pulper/finisher removes solids such as skins, seeds and/or other fibrous material from the tomatoes. The pulp and fibers remaining within the finished tomatoes or "juice" are reduced to a specific size. Pulping-finishing generally occurs at a  
35 temperature of approximately 190 to 210 degrees Fahrenheit if the tomato pieces are subjected

1 to hot breaking. If the tomato pieces are subjected to cold breaking, the pulping-finishing process can occur at approximately 150 to 170 degrees Fahrenheit.

5 Pulping and finishing tomato pieces results in a tomato "juice" or pulp product ("tomato juice"). However, those persons of ordinary skill in the art will recognize that "juice" can be formed by techniques besides pulping and finishing, e.g., by repeated chopping, crushing, or other actions to form juice. Thus, the tomato juice is not necessarily a product of a pulping/finishing step.

10 The tomato juice can be initially concentrated, if necessary, by removing water with an evaporator in step 520. The degree of evaporation can depend on the initial liquid content of the tomato juice. For example, hot tomato juice or juice processed with hot breaking can be exposed to a vacuum (e.g., 10-30°Hg) to remove a percentage of water from the juice. Thus, the more water that is removed from the juice, the more viscous or resistant to flow the juice becomes.

15 Continuing with step 525, tomato juice is separated or fractionated into serum and cake portions with a decanter. One example decanter configuration for separating the portions is a weir and scraper or auger configuration. The cake portion is more viscous and contains higher percentages of insoluble solids and pectins of the tomato. The cake portion can comprise about 5% to 35% of the total tomato juice stream. Further, the cake portion typically includes a large percentage or majority of lycopene and other "color" compounds. The cake portion includes about 5%-60% insoluble solids by weight and about 3-16% soluble solids by weight. The cake  
20 portion can have a concentration of about 3 to 13 brix.

The serum portion of the tomato juice stream is less viscous than the cake that includes lower percentages of insoluble solids and pectin of the tomato compared to the cake portion. The serum portion can comprise approximately 65% to 95% of the total tomato juice stream by weight. The serum portion includes about 0 (trace) amount to about 10% insoluble solids by  
25 weight and about 3%-17% soluble solids by weight. Further, the serum portion can have a concentration of about 3-16 brix.

In step 530, the serum portion 435 is concentrated. More specifically, the thin, less viscous serum fraction can be concentrated by removing water with, for example, a smaller, less robust (and less expensive) evaporator compared to evaporators used in known systems which  
30 process unfractionated tomato juice. Examples of evaporators that can be used to concentrate the serum portion in step 445 include, but are not limited to, a rising film evaporator, a falling film evaporator, a thin film evaporator, and other concentrating units such as a reverse osmosis concentrator or a direct osmosis concentrator. The serum portion can be evaporated more easily than unfractionated juice because the thinner serum can be re-circulated in the evaporator more  
35 often and more easily, resulting in improved heat transfer. Additionally, maintenance and cleaning and related costs can be reduced. As a result of lower levels of insoluble portions in the

1 concentrated juice, less or no cake is burned onto evaporator surfaces. Utilizing smaller and less  
robust evaporators is also beneficial because of lower capital and operating costs. Smaller  
evaporators can also operate under reduced heat or temperatures, vacuum requirements, re-  
circulation requirements, and residence time to evaporate a given amount of water from the  
5 serum.

If necessary, in step 535, the cake portion can be concentrated. The thicker, more viscous  
cake portion contains higher percentages of insoluble solids and is also subjected to reduced heat,  
vacuum, re-circulation shear, and residence time. For example, instead of processing the thicker  
cake portion in the unfractionated stream with an evaporator, the cake can be concentrated using  
10 a drying mechanism such as a model no. 1 or a model no. 5 drier available from MCD  
Technologies, Inc., Tacoma, Washington. As a result, less cake "burn" occurs since a higher-  
powered evaporator is no longer necessary to concentrate the juice stream.

The fractionated cake and concentrated serum portions are re-combined in step 540 with  
a combination unit, e.g., a positive displacement pump or an in-line static mixer as previously  
15 described. Re-combining the cake and serum portions results in the formation of a "re-  
combined" or "second" tomato stream 545. The brix concentration of the second stream 545 is  
about 15 to 40 brix. During re-combination, all or a portion of the cake portion can be added to  
the concentrated serum. For example, 50% - 100% of the cake can be re-combined with the  
concentrated serum. Indeed, other cake percentages can be used depending on particular needs  
20 and desired viscosity (viscosity increases as percentage of cake increases). Increasing cake  
quantities lowers the brix of the re-combined stream since the cake brix is approximately 3 to 20  
brix, preferably 3-13 brix, while the serum brix is about 22-70 brix. As a result, the  
concentration of the re-combined stream 545 can be about 15 to 40 brix, preferably about 22-40  
brix.

25 Continuing with Figure 5B, the second or re-combined stream 545 can be further  
concentrated in step 550, if necessary, and sterilized as necessary in step 555. The re-combined  
stream is cooled if necessary in step 560. For example, the stream can be transferred to a flash  
cooler. Alternatively, a heat exchanger or other process may be used to cool the paste. Those  
persons of ordinary skill in the art will recognize that different cooling systems can be utilized.  
30 The combined stream can be packaged in step 565 or storage, shipping, sale, or consumption.  
As a result, the resulting tomato paste product produced with the re-combined stream has  
improved color, flavor and viscosity compared to tomato paste formed by processing  
unfractionated tomatoes.

Figures 6A-B illustrate an alternative to the method shown in Figures 5A-B. In Figures  
35 6A-B, the initial steps performed in the alternative method are the same as the previously  
describe method. Namely, in steps 500-520, tomatoes are chopped, subjected to enzyme removal

1 or breaking, processed using a pulper/finisher, and subjected to preliminary evaporation, as  
necessary. The tomato stream is fractionated 525 into serum and cake portions as previously  
described. The serum portion is concentrated in step 530, and the cake portion can be  
concentrated as necessary in step 535.

5 Instead of re-combining the cake and serum streams as in the method of Figures 5A-B,  
the serum and cake portions in the alternative embodiment are individually processed.  
Specifically, in step 600, the serum portion can be further concentrated if necessary. In steps 605,  
the serum and cake portions are sterilized as necessary. The sterilization step may be optional  
if the concentration is sufficiently high to limit microbiological activity. In this alternative case,  
10 refrigerated storage may be used. In step 610, the serum and cake portions are cooled. Finally,  
in step 615, the serum and cake portions can be individually packaged or further processed. The  
fractionated cake and serum portions are packaged for subsequent storage, shipping, sale, or  
consumption. For example, the tomato portions are transferred to bulk bag in bins, storage tanks  
or other storage containers. The final serum product can have a concentration of about 22-75  
15 brix. The final cake product can have a concentration of about 3-13 brix or can be dehydrated  
into a powder with less than 10% moisture.

The previously described method and system result in a tomato paste with enhanced  
attributes compared to tomato paste and tomato products produced by known systems. For  
example, tomato paste produced with the present system and method has improved color, flavor,  
20 and viscosity. Moreover, the improved tomato paste product is produced in a more cost efficient  
manner since smaller and less expensive and more energy-efficient evaporators can be used to  
fractionate the tomato juice into a more viscous and less viscous portions. As a result, reduced  
"burn on" occurs in the evaporator. The evaporator can concentrate the thinner serum, whereas  
a drying mechanism can evaporate or concentrate the cake as necessary, thereby reducing cake  
25 burn which would otherwise occur when processing unfractionated streams. Moreover, since the  
serum is significantly thinner than an unfractionated stream, the serum can be concentrated with  
the evaporator more quickly than the time required to concentrate an unfractionated stream. As  
a result, residence time of the products in the evaporator decreases and operating costs are  
reduced. Thus, the present system and method provide flexibility in selecting system portions,  
30 is more cost and time efficient, and produces higher quality tomato paste, serum, cake and other  
products similar or related to tomatoes.

Although references have been made in the foregoing description to various  
embodiments, persons of ordinary skill in the art of food preparation methods and systems will  
recognize that insubstantial modifications, alterations, and substitutions can be made to the  
35 described embodiments without departing from the invention as claimed in the accompanying  
claims. Thus, while the preferred embodiment is described as utilizing tomatoes, those skilled

1 in the art will recognize that other similar tomato products and fruits and vegetables having  
similar viscosity characteristics can be processed. Further, persons of ordinary skill in the art will  
recognize that the example ranges of concentrations, temperatures, durations, and vacuum are  
recited for purposes of explanation. Indeed, other ranges can be utilized depending on the system  
5 portions and desired product characteristics. Moreover, those persons of ordinary skill in the art  
will recognize that various decanters, evaporators, driers and re-combiners can be used to process  
fractionated or re-combined cake and serum streams.

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## 1 WHAT IS CLAIMED IS:

1. A method of processing tomatoes to form a tomato product, comprising:  
separating a tomato stream into first and second portions, said first portion having  
5 a greater viscosity than said second portion;  
concentrating said second portion; and  
combining said first portion and said concentrated second portion to yield the  
tomato product.
- 10 2. The method of claim 1, wherein separating said tomato stream further comprises  
separating a tomato juice stream formed from raw tomatoes.
3. The method of claim 1, wherein said first portion comprises a cake portion.
- 15 4. The method of claim 1, wherein said second portion comprises a serum portion.
5. The method of claim 1, wherein said first portion comprises about 5% to 35% of  
said tomato stream by weight.
- 20 6. The method of claim 1, wherein said first portion comprises about 5% to 60%  
insoluble solids by weight.
7. The method of claim 1, wherein said first portion comprises about 3% to 16%  
soluble solids by weight.
- 25 8. The method of claim 1, wherein said first portion has a concentration of about 3  
to 13 brix.
9. The method of claim 1, wherein said first portion includes a majority of a color  
30 compound relative to said second portion.
10. The method of claim 9, wherein said color compound comprises lycopene.
11. The method of claim 1, wherein said first portion includes a majority of insoluble  
35 solids relative to said second portion.

1           12. The method of claim 1, wherein said second portion comprises about 65% to 95%  
of said tomato stream by weight.

5           13. The method of claim 1, wherein said second portion comprises about 0.01% to 10%  
insoluble solids by weight.

          14. The method of claim 1, wherein said second portion comprises about 3% to 17%  
soluble solids by weight.

10          15. The method of claim 1, wherein said second portion has a concentration of about  
3 to 16 brix.

          16. The method of claim 1, wherein said concentrated second portion has a  
concentration of about 22 to 75 brix.

15          17. The method of claim 1, before separating said stream into said first and second  
portions, further comprising processing the tomato product into said tomato stream.

20          18. The method of claim 17, wherein processing the tomato product further comprises:  
chopping one or more tomatoes into tomato pieces; and  
removing solids from said tomato pieces.

          19. The method of claim 18, wherein removing said solids further comprises filtering  
tomato skins and seeds with a filter screen.

25          20. The method of claim 1, further comprising inactivating one or more enzymes in  
said stream.

30          21. The method of claim 20, wherein said one or more enzymes is pectin galacturonase  
or pectin methyl esterase.

          22. The method of claim 20, wherein inactivating said one or more enzymes further  
comprises subjecting said stream to a temperature of about 150 to 230 degrees Fahrenheit for a  
period of about 15 seconds to 10 minutes.

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1           23. The method of claim 1, wherein separating said stream into said first and second portions further comprises fractionating said tomato stream using a decanter.

5           24. The method of claim 23, wherein said decanter includes a weir plate and a scraping mechanism, and separating said first and second portions further comprises  
rotating said decanter to force said first portion against an inner surface of said decanter,  
separating said first and second portions with said weir, and  
removing said first portion collected along said inner surface with said scraping  
10 mechanism.

25. The method of claim 24, further comprising removing said first portion collected against said inner surface through a first portion outlet of said decanter.

15           26. The method of claim 24, further comprising removing said second portion within said decanter through a second portion outlet of said decanter.

27. The method of claim 1, wherein concentrating said second portion further comprises concentrating said stream at a temperature of about 190 to about 210 degrees  
20 Fahrenheit in a vacuum of about 10 to about 30 Hg.

28. The method of claim 1, wherein concentrating said second portion further comprises dehydrating said second portion with an evaporator.

25           29. The method of claim 28, wherein said evaporator is a thin film evaporator, a rising film evaporator, a falling film evaporator, a reverse osmosis concentrator, or a direct osmosis concentrator.

30           30. The method of claim 1, further comprising concentrating said first portion.

31. The method of claim 30, wherein said first portion is concentrated with a drier.

32. The method of claim 1, wherein the tomato product comprises tomato paste.

35           33. A system for processing a tomato stream to form a tomato product, comprising:  
a decanter configured to

1                   receive the tomato stream, and  
                  fractionate the stream into a first portion and a second portion, wherein said  
first portion has a greater viscosity than said second portion;  
                  an evaporator for concentrating said second portion; and  
5                   a combination unit for combining said first portion and said concentrated second  
portion to form the tomato product.

                  34. The system of claim 33, wherein the tomato stream comprises a tomato juice stream  
formed from raw tomatoes.

10

                  35. The system of claim 33, wherein said first portion comprises a cake portion.

                  36. The system of claim 33, wherein said second portion comprises a serum portion.

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                  37. The system of claim 33, wherein said first portion comprises about 5% to 35% of  
the tomato stream.

                  38. The system of claim 33, wherein said first portion comprises about 5% to 60%  
insoluble solids.

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                  39. The system of claim 33, wherein said first portion comprises about 3% to 16%  
soluble solids.

                  40. The system of claim 33, wherein said first portion has a concentration of about 3  
25 to 13 brix.

                  41. The system of claim 33, wherein said first portion includes a majority of a color  
compound relative to said second portion.

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                  42. The system of claim 41, wherein said color compound comprises lycopene.

                  43. The system of claim 33, wherein said first portion includes a majority of insoluble  
solids relative to said second portion.

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                  44. The system of claim 33, wherein said second portion comprises about 65% to 95%  
of the tomato stream by weight.

- 1           45. The system of claim 33, wherein said second portion comprises about 0.01% to 10% insoluble solids by weight.
- 5           46. The system of claim 33, wherein said second portion comprises about 3% to 17% soluble solids by weight.
47. The system of claim 33, wherein said second portion has a concentration of about 3 to 16 brix.
- 10          48. The system of claim 33, wherein said concentrated second portion has a concentration of about 22 to 75 brix.
49. The system of claim 33, further comprising a processing system for processing tomatoes into the tomato stream.
- 15          50. The system of claim 49 wherein said processing system comprises a chopper for cutting tomatoes into tomato pieces; and a pulper for removing solids from said tomato pieces.
- 20          51. The system of claim 50 wherein said pulper is configured to remove solids comprising skins and seeds by filtering said solids with a filter screen.
52. The system of claim 33, further comprising an enzyme deactivation system for inactivating one or more enzymes in the tomato stream.
- 25          53. The system of claim 52, wherein said one or more enzymes is pectin galacturonase or pectin methyl esterase.
54. The system of claim 52, wherein said enzyme inactivation system is configured to inactivate said one or more enzymes by subjecting the stream to a temperature of about 150 to 230 degrees Fahrenheit for a period of about 15 seconds to 10 minutes.
- 30          55. The system of claim 33, wherein said decanter includes a weir plate and a scraping mechanism, said weir plate separating said first and second portions when said decanter is rotated, and said scraping mechanism removing said first portion collected along an interior surface of said decanter.
- 35

1           56. The system of claim 33, wherein said decanter defines a first portion outlet through which said first portion collected against said inner surface of said decanter is removed.

5           57. The system of claim 33, wherein said decanter defines a second portion outlet through which said second portion is removed.

          58. The system of claim 33, wherein said evaporator concentrates said second portion at a temperature of about 190 to about 210 degrees Fahrenheit in a vacuum of about 10 to 30 Hg.

10          59. The system of claim 33, wherein said evaporator is a thin film evaporator, a rising film evaporator, a falling film evaporator, a reverse osmosis concentrator or a direct osmosis concentrator.

15          60. The system of claim 33, further comprising a drier for concentrating said first portion.

          61. The system of claim 33, wherein said tomato product comprises tomato paste.

20          62. A method of processing a food substance affected by viscosity to form a food product, comprising:

          separating the food substance into first and second portions, said first portion having a greater viscosity than said second portion;

          concentrating said second portion; and

25          combining said first portion and said concentrated second portion to form the food product.

          63. The method of claim 62, wherein said food substance comprises one or more tomatoes and said food product comprises a tomato paste.

30          64. The method of claim 62, wherein said food substance comprises one or more apples and said food product comprises an apple puree.

          65. The method of claim 62, wherein said food substance comprises a chili food item and said food product comprises a chili paste.

35

1           66. The method of claim 62, wherein said food substance comprises one or more peas  
and said food product comprises a pea soup.

5           67. A system for processing a food substance to form a food product, comprising:  
a decanter configured to  
receive said food substance and  
fractionate said substance into a first portion and a second portion, wherein  
said first portion has a greater viscosity than said second portion;  
an evaporator for concentrating said second portion; and  
10           a combination unit for combining said first portion and said concentrated second  
portion to form the food product.

15           68. The system of claim 67, wherein said food substance comprises one or more  
tomatoes and said food product comprises a tomato paste.

          69. The system of claim 67, wherein said food substance comprises one or more apples  
and said food product comprises an apple puree.

20           70. The system of claim 67, wherein said food substance comprises a chili food item  
and said food product comprises a chili paste.

          71. The system of claim 67, wherein said food substance comprises one or more peas  
and said food product comprises a pea soup.

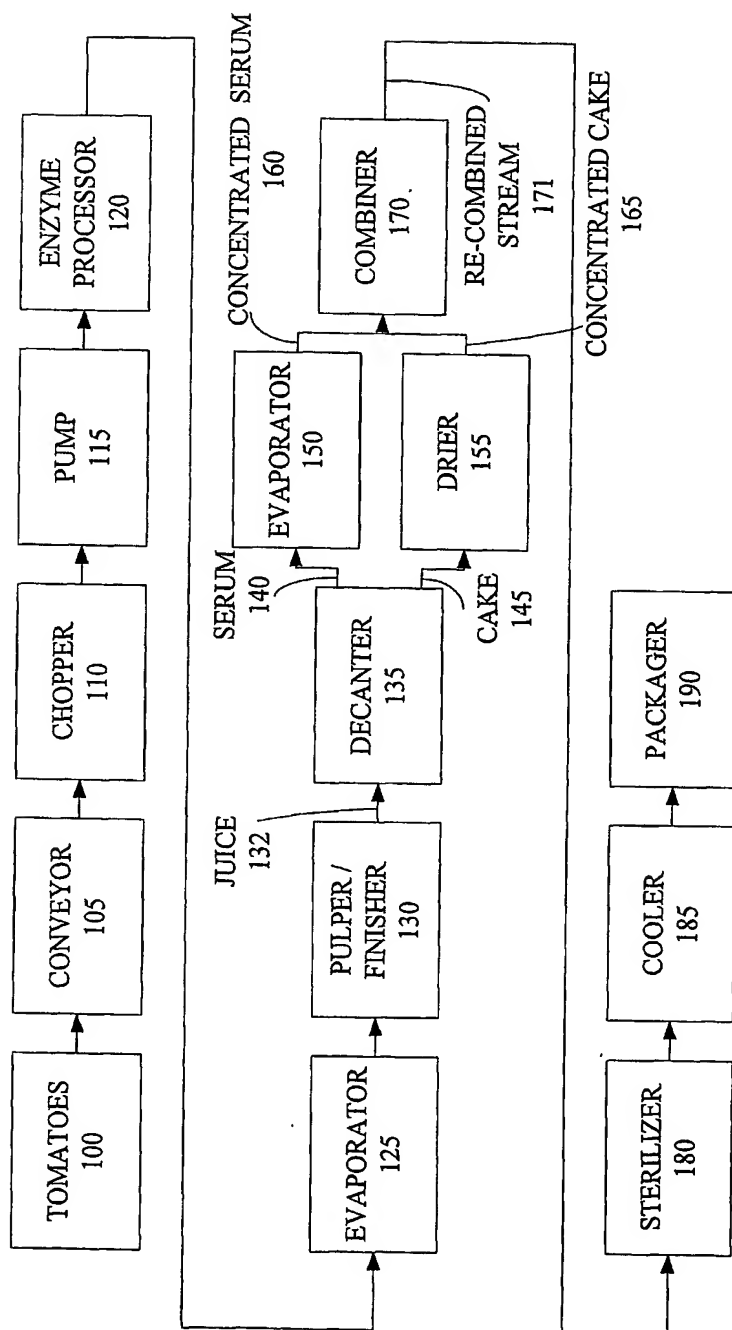


FIG. 1



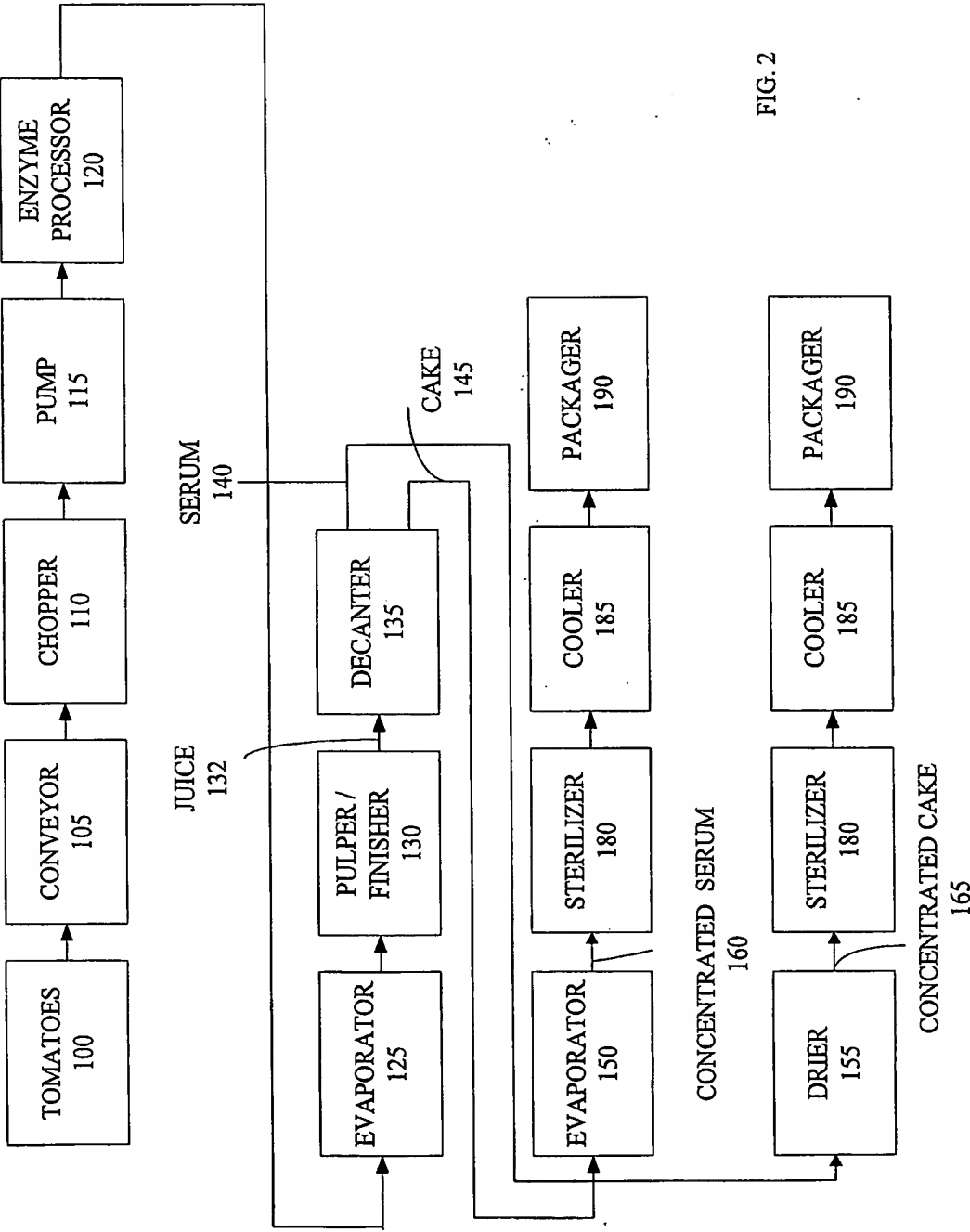


FIG. 2

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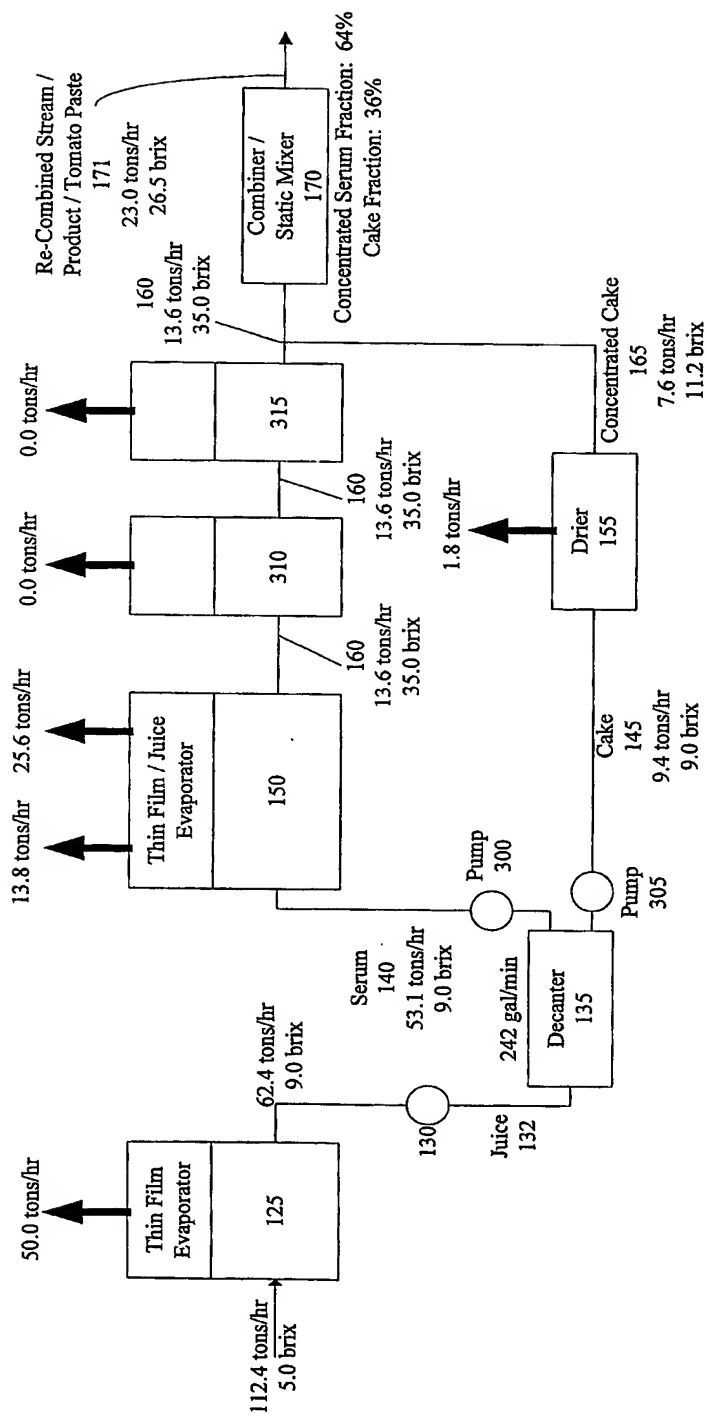


FIG. 3

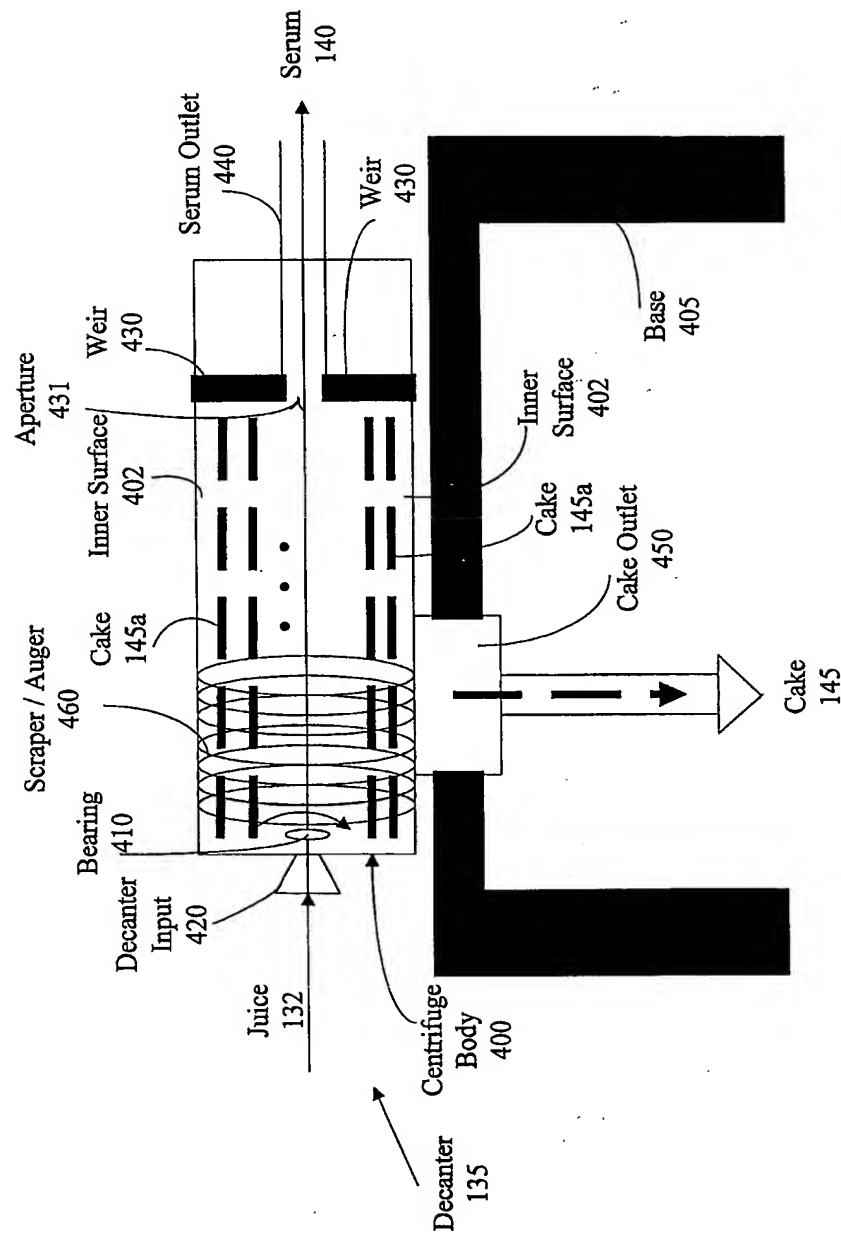


FIG. 4

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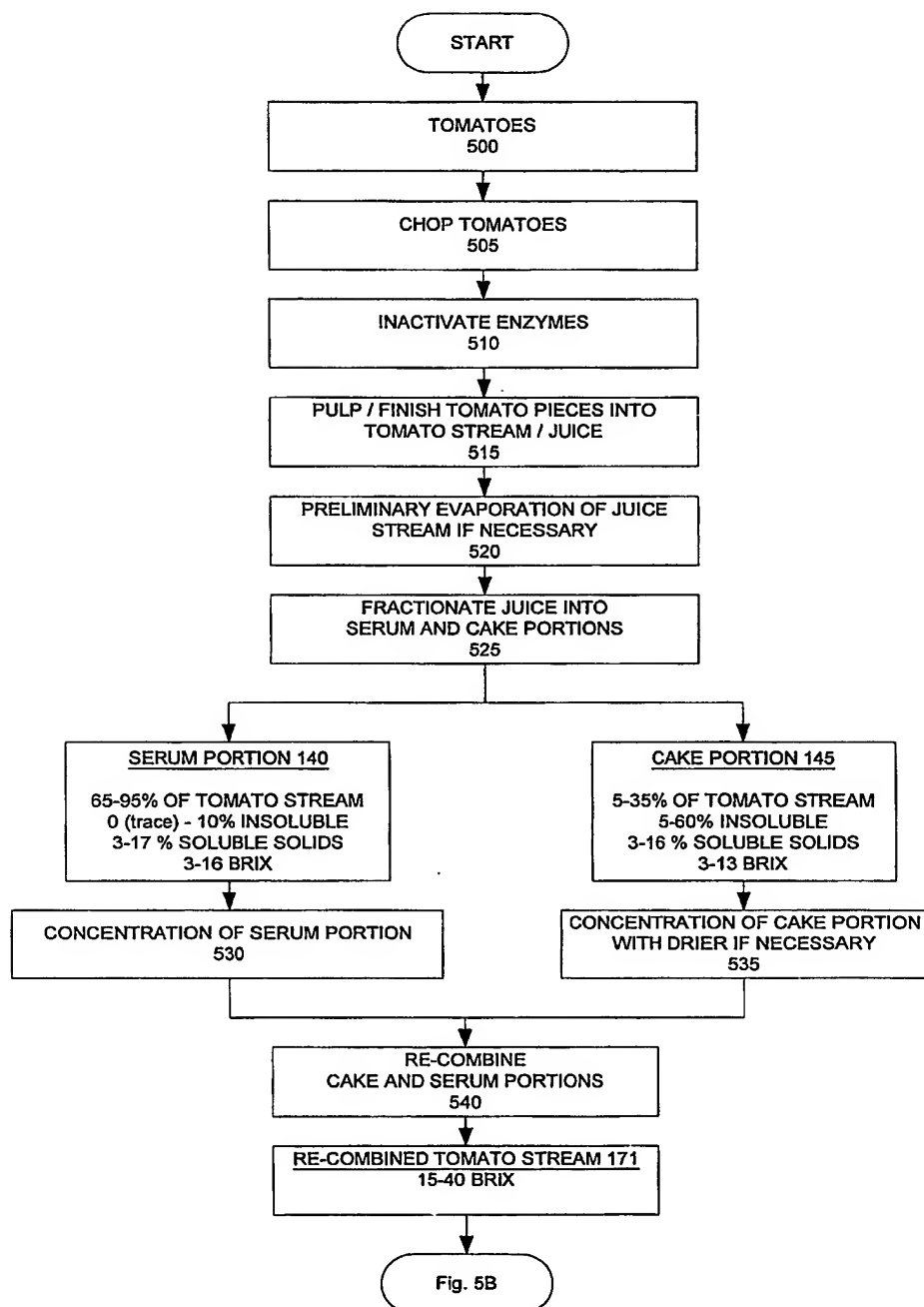


FIG. 5A

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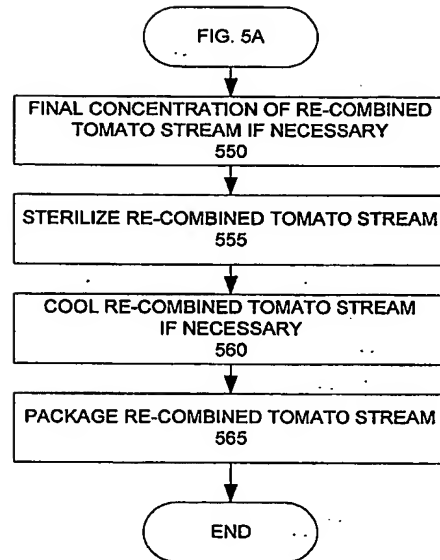


FIG. 5B

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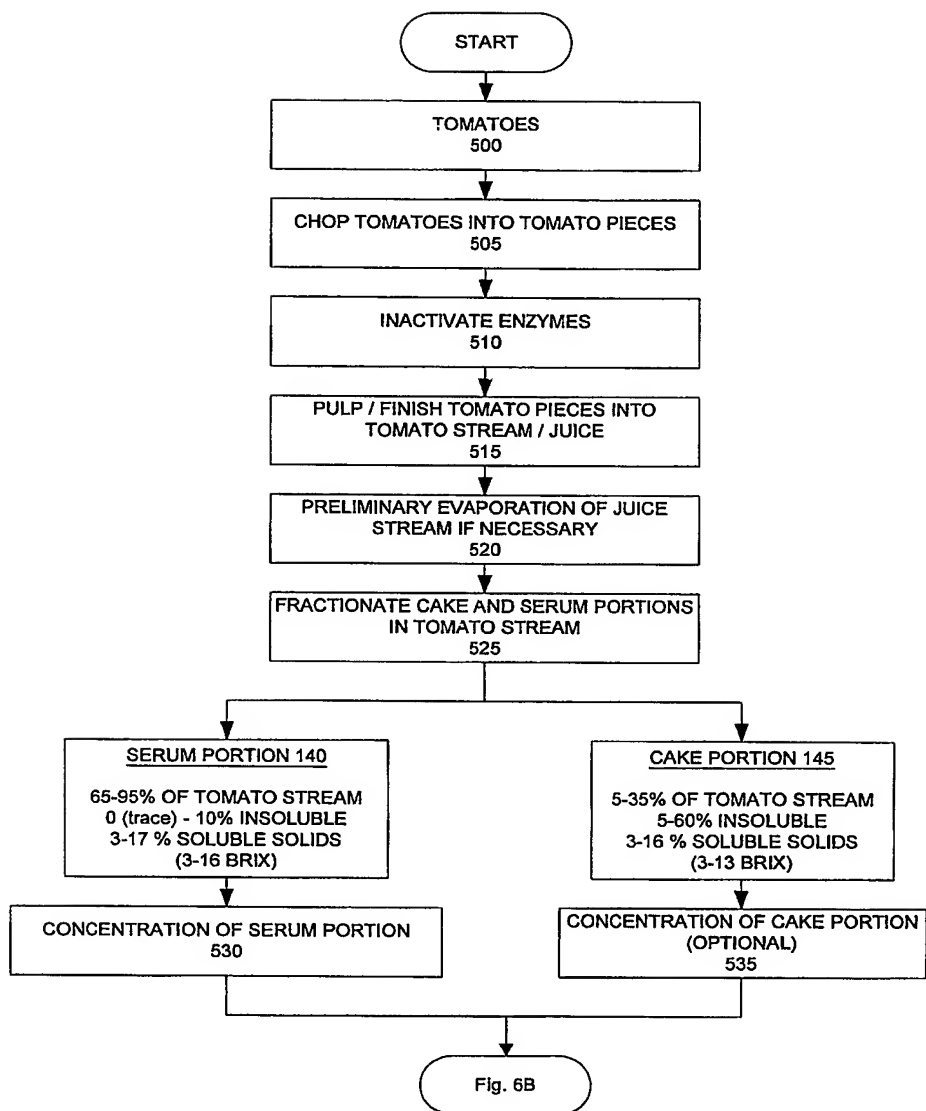


FIG. 6A

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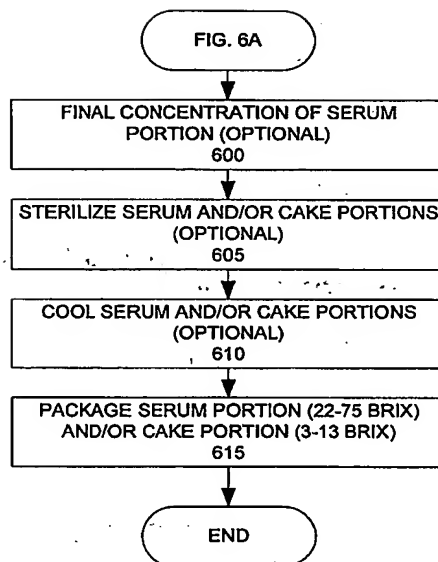


FIG. 6B

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